Sector Cache Optimizations for the K Computer

Swann Perarnau, Mitsuhisa Sato
RIKEN AICS, University of Tsukuba

Sector Cache on the SPARCVIIIfx

- On-demand split of the shared L2 cache.
- User controlled mapping between accesses and sectors.
  - → Isolation of thrashing accesses.
  - → Select and keep useful data in cache.

Issues

- Low-level compile-time API.
- Hard to predict impact on performance.
- Little support from compiler and performance analysis tools.

Current Sector Cache API

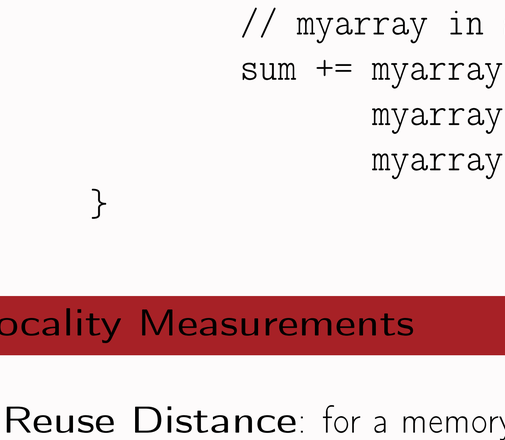
```
double myarray[NSIZE];
double otherarray[NSIZE];

void mywork(void)
{
        int i;
        double sum = 0;
#pragma statement cache_sector_size 1 11
#pragma statement cache_subsector_assign myarray
        for(i = 2; i < NSIZE-2; i++)
        {
                // myarray in sector 1
                sum += myarray[i-2] + myarray[i-1] +
                       myarray[i]   + myarray[i+1] +
                       myarray[i+2] + otherarray[i];
        }
}
```

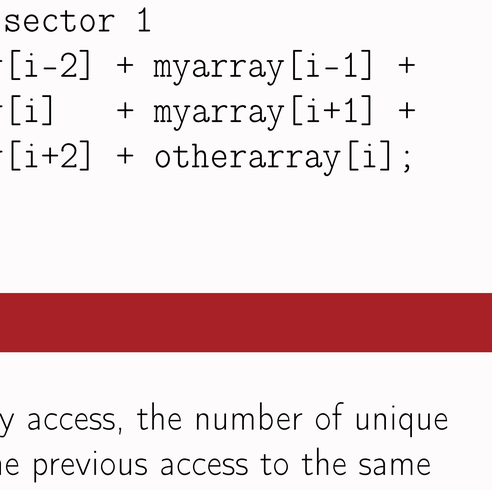
Locality Measurements

Reuse Distance: for a memory access, the number of unique memory locations touched since the previous access to the same location.
→ an architecture-independent measure closely related to the cache misses triggered by an application.
→ use it to measure consequences of isolating one structure by itself with the sector cache.

Validating the Framework: a toy example



Reuse Distances of Each Structures



Optimizations for all Sector Configurations

Our Goals

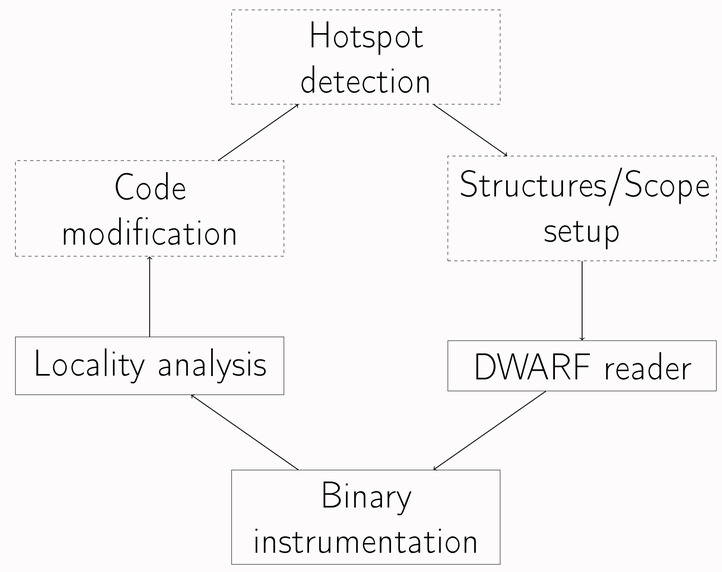
Assess applicability of the sector cache to optimize HPC applications.

- Study potential optimization strategies.
- Help users find good sector cache optimizations.
- Aim for as much automation as possible.

Results

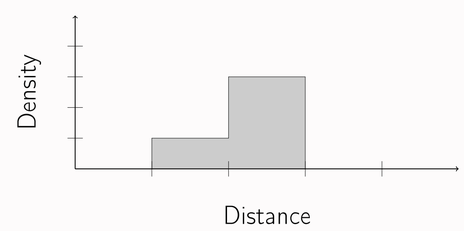
- efficient cache optimization of classical HPC benchmarks.
- framework for locality analysis and optimization of HPC applications.
- on-going automation, already little user action required.

Framework Overview



Reuse exemple

Access :	Distance :
load 0x10	∞
load 0x20	∞
load 0x30	∞
load 0x10	2
load 0x20	2
load 0x10	1
load 0x30	2



Optimizing the NAS Parallel Benchmarks

Benchmark	Function	Isolated Variables	Sector Size	Miss Reduction (%)	Runtime Reduction (%)
CG	conj_grad	p	(1,11)	19	10
LU	ssor	a,b,c,d	(2,10)	48	8
	blts	ldz,ldy,ldx,d		75	10
	buts	d,udx,udy,udz		18	3
	jacld	a,b,c,d		64	14
	jacu	a,b,c,d		57	6

Acknowledgements

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